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(54) ## Incubator.

(57) The incubator (10) for neonatology comprises a chamber (PR) enclosed by a bottom shell (12) and a transparent top casing (11); the top casing (11) covers a rectangular area of the bottom shell (12); a pair of superimposed and substantially rectangular trays (14, 16) is provided for air distribution and each tray (14, 16) has two longitudinal side walls (145, 165; 146, 166) two transverse end walls (141, 161; 142, 162) and a bottom (143, 164); the trays (14, 16) are arranged with their bottoms (143, 164) in a parallel and distanced relation when in normal operating condition; the lower tray (14) has substantially the same length as the casing-covered area but a smaller width; the upper tray (16) is shorter and wider than the lower tray (14) but has a smaller width than the casing-covered area; a first air-conduction space (LR) is formed between bottom shell (12) and lower tray (14) and a second air-conducting space (AR) is formed between lower tray (14) and upper tray (16); two longitudinal gaps (ZS¹, ZS²) are formed between tray (14) and bottom shell (12), each communicating with the first air-conducting space (LR) and extending over a predominant portion of the length of the casing- covered area; two transverse air-passing gaps (AS¹, AS²) are formed between the end walls (141, 161; 142, 162) of upper tray (16) and lower tray (14), each communicating with the second air-conducting space (AR) and extending over a major portion of the width of the casing-covered area; the blowing end of blower (15) is connected with one air-conducting space (LR, AR) and the suction end is connected with the other.

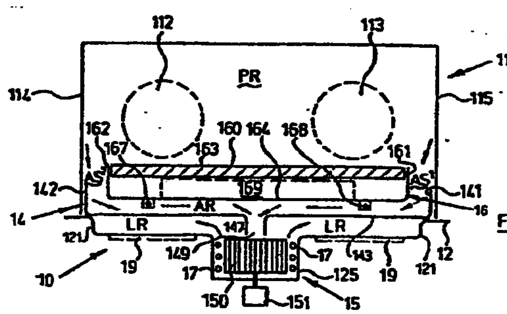


FIG 1a

EP 0 162 375 A1

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# INCUBATOR

This invention relates to incubators for neonatology of the type known and used for intensive care of newborns afflicted by abnormally low weight or other defects due to premature birth, incomplete development, sickness, malformation and other pathological conditions of newborns.

In essence, incubators are aerated and heat-controlled (e.g. 38°C ± 0.5°C) chambers formed by a generally elongated rectangular bottom shell and a transparent top or cover casing normally provided with a number of circular ports connected with the open ends of rubber gloves or similar membrane-type closures providing for sterile handling of the baby.

Generally, the top casing of an incubator can be removed from the bottom shell, e.g. by pivoting, and the front wall of the casing is pivotable as well for removing or inserting the patient.

When the incubator chamber is in operating position, air or oxygen-enriched air heated to constant temperature is passed through the chamber to maintain the baby at optimum ambient conditions; humidification by evaporators, atomizers, etc. is conventional.

Prior art incubators suffer from a number of defects, however, notably as regards lack of uniform airflow; this causes an undesirable temperature distribution because the air that is circulated or passed through the chamber is also the medium that heats the chamber so that an inhomogeneous air distribution leads to non-uniform heat distribution.

At the same time, conventional air-guiding means in prior art incubators, such as vanes, perforated panels, and grids, are disadvantageous in view of sterility because they are difficult to clean and tend to promote accumulations of airborne infection sources; in addition, the air distribution means of conventional incubators tend to be bulky or complicated which, in turn, makes the incubators expensive, both as regards manufacture and maintenance.

Accordingly, it is a main object of the present invention to provide for an incubator that is free of the above disadvantages and combines the advantages of a smooth and uniform airflow that is draft-free, i.e. essentially laminar, with an extremely simple yet effective construction of novel and improved air-guiding means.

A further object of the invention is to provide for an incubator in which the air-guiding means are formed by only a few and smooth-surfaced components that can be easily mounted for assembly and easily dismounted for cleaning and disinfection.

Yet a further object of the invention is to provide for the above mentioned advantages in a relatively compact incubator that can be manufactured and operated economically.

The above objects are achieved according to the invention by an incubator of the type having a chamber substantially defined or enclosed by a bottom shell and a transparent top casing or hood, both of which may be of conventional structure, heating and aerating means, such as a motor-driven blower plus heating elements, and air distribution means for passing a stream of heated air through said chamber. The incubator according to the invention is characterized by a novel construction of the air distribution means as defined in claim 1.

Preferred embodiments of the incubator are defined in claims 2 to 10.

The transparent top casing (also termed "hood" for brevity) of the incubator has a generally box-like shape and covers a substantially rectangular area of the bottom shell; because of the patient's body shape the rectangular area is elongated, i.e. its length is greater than its width, e.g. by a factor of 1.2 to 2. Width and height dimensions of the hood may be about equal; typically, the width:height ratio of the hood is in the range of from 0.8 to 1.2, this being a matter of choice. The width and length dimensions of the hood-covered rectangular area of the bottom shell are essential parameters for the trays however.

Generally, the bottom shell will be shaped to form recesses for receiving a ventilator or blower plus heating means and evaporators, and may have passages for air inlets and the like conventional means for operating an incubator; preferably the line of contact between the hood and the bottom shell will be in a horizontal plane defined, for example, by the lower edge of the top casing and a corresponding support area of the bottom shell. The bottom ——————————————————————

shell may be an integral or a composite structure of two or more shell portions.

According to the invention, the incubator chamber includes a pair of superimposed and substantially rectangular trays, the lower of which will also be termed "first tray" or "air-guiding tray" because its primary function is to guide the aeration stream or air flow before its passage into the chamber and after its passage through the chamber. "Passage" of air through the chamber is understood to include partial or substantial recirculation.

The upper tray is also called "second tray" or "support tray" since this tray also serves to hold a generally flat layer of a relatively soft material which, in turn, supports the baby.

As used herein, the term "tray" generally refers to structures having a generally flat bottom which when in normal operating position extends substantially in a horizontal direction, and further having two mutually opposed longitudinal side walls and two mutually opposed transverse end walls that are shorter than the longitudinal side walls of the trays.

When a tray is in normal operating position, side and end walls will extend upwards from the bottom.

According to the invention, the lower or first and the upper or supporting tray are arranged with their bottoms in a generally parallel and distanced (typically from 10 to 150 mm) relation when in normal operating position. However, the incubator may include mechanical or pneumatic positioning means for elevating the head end or/and the foot end of the support

tray so that the patient may be held in an inclined (typically up to 20°) position "head up" or "head down".

Further, for removal of the patient when the top casing or its lid is in "open" position, the upper or support tray will preferably be mounted on slide rails or the like means so that this tray may be slidingly moved from its normal operating position within the chamber into a charge or discharge position outside of the chamber.

According to an essential feature of the invention, the first or lower tray will have substantially the same length as the hood-covered rectangular area of the bottom shell; in other words, the lower tray will be substantially as long as the inner length of the top casing; typically, the difference between length of the lower tray and the (inner) length of the transparent top casing will be in the range of from 5 to 20 mm.

The upper tray is shorter than the lower tray, typically by 40 to 400 mm, but wider than the latter, typically by 30 to 300 mm. The upper tray is wider than the lower tray but not as wide as the hood-covered rectangular bottom shell area; typically, this difference between the width of the hood-covered shell area and the width of the upper tray will be in the range of from 20 to 200 mm.

Further, according to an essential feature of the invention, the lower or air-guiding tray separates two air-conducting spaces: the lower or first of these spaces is formed between the bottom shell and the lower tray; the upper or second air-conducting space is formed between lower and upper tray.

Preferably, the upper or second air-conducting space is formed essentially by the interspace between upper and lower tray while the lower air-conducting space is formed essentially by a generally rectangular interspace between the lower tray and a substantially rectangular recessed portion of the bottom shell; preferably, this recessed portion of the bottom shell is somewhat shorter, typically by 25 to 250 mm, than the lower tray, but somewhat wider than the latter, typically by 20 to 200 mm.

According to the invention, a pair of longitudinal air gaps is formed between the lower tray and the bottom shell; each of these gaps communicates with the first or lower air-conducting space and extends over a predominant portion, at least, typically over more than 50 % and preferably over at least about 70 %, of the length of the (inner) sides of the top casing, i.e. the length of the rectangular bottom shell area covered by the top casing.

Further, according to the invention, a pair of transverse air-passing gaps is formed between the end walls of the upper tray and the lower tray; each transverse gap communicates with the second air-conducting space and extends over a major portion, at least, typically about 30 % and generally at least about 50 %, of the width of the rectangular bottom shell area.

Finally, an air blower of the type known per se, e.g. a radial blower, is provided such that its blowing end opens into one air-conducting space while its suction end opens into the other air-conducting space; preferably, the blowing end of the blower opens into the first or lower air-conducting space while the suction end is connected with, or acts upon, the upper air-conducting space. In this preferred embodiment, the bottom of the upper tray is substantially closed while the

bottom of the lower tray has an opening, preferably at or near its geometric center, leading via a short conduit to the suction end of the blower.

The invention will be explained in more detail with reference to the annexed drawings which illustrate preferred embodiments of the invention and wherein:

Figure 1a is a side view of a diagrammatic presentation of an incubator according to the invention;

Figure 1b is a top view of the incubator shown in Fig. 1a;

Figure 1c is a front view of the incubator shown in Fig. 1a;

Figure 1d is a perspective view of a diagrammatic representation of two interfitting trays as arranged within an incubator according to the invention, and

Figure 2 is a semi-diagrammatic perspective view of an inventive incubator mounted on a movable support structure.

Describing now the drawings, the incubator 10 which is illustrated diagrammatically in Figure 1a in side view comprises a transparent top casing 11 made of a transparent plastic or glass and being provided in a conventional manner with pivoting or securing means (not shown) for connecting the top casing 11 with and disconnecting it from bottom shell 12; one longitudinal side wall may be pivotably connected with the top casing as shown in broken lines for side wall 117 in Fig. 1c and the hinge may be either near a top edge or a bottom edge of casing 11.

Casing 11 further comprises a number of conventional circular ports, e.g. a total of six, only two being shown as ports 112, 113 in broken lines. Each such port will be closed with a membrane, e.g. in the form of a glove, to permit sterile handling of the patient within incubator 10. Additional smaller ports with overlapping membranes can be provided in a conventional manner to permit passage of conduits or leads for infusion or monitoring. Sealing joints between the port openings of top casing 11 and the membranes are conventional and not shown.

The lower edges of transverse end walls 114, 115 and of longitudinal side walls 117, 118 (Fig. 1b) contact bottom shell 12, generally without an intermediate seal. Bottom shell 12 can be made of metal, e.g. steel sheet which may be of stainless quality or is provided with a coating, or of plastic, e.g. fiber-reinforced thermoset polyester or epoxy resin; shell 12 has a first recessed portion 121 that cooperates with bottom 143 of lower tray 14 to form the first air-conducting space LR. A second recessed portion 125 of bottom shell 12 forms an open-ended chamber for receiving a blower 15 comprising a rotor 150 driven by a motor 151 which, in turn, is connected by means of

an anti-vibration socket (not shown) or the like means that minimize vibration. Rotor 150 is formed in a conventional manner by a number of outwardly slanted blades mounted between a closed lower rotor disc and an annular upper rotor disc; a space free of blades is provided at the center of the rotor.

When motor 151 drives rotor 150, the rotating blades will cause a suction effect at the rotor center and a blowing effect at the rotor periphery.

Electrical heating elements 17 are provided between the periphery of rotor 150 and the adjacent wall of chamber 125 so that the air passing from rotor 150 will be heated. Control means for the heating elements 17 are conventional and not shown.

The lower tray 14, e.g. made of a molded plastic of the thermoplastic or the crosslinked family, with or without fiber reinforcement, is formed by two transverse end walls 141, 142, two longitudinal side walls 145, 146 and bottom 143 which, in turn, is substantially closed except that an opening 149 is provided near its geometrical center with a tubular extension or conduit 147 extending through the first air-conducting space LR to the suction end of rotor 150.

Upper tray 16 is formed by two transverse end walls 161, 162, two longitudinal side walls 165, 166 and bottom 164; tray 16 is supported by two guides 167, 168 for sliding motion along two rails or rods (not shown) connected to the lower tray 14 so that upper tray 16 can be displaced horizontally relative to lower tray 14 when lid 117 of top casing 11 is opened.

A drawer-type insert 169 (shown in broken lines) is provided to receive X-ray film material to permit taking X-ray photographs of the patient within the incubator. A resilient pad 163 is inserted into tray 16 to serve as support face 160 for the patient.

Lower tray 14, the air-guiding tray, is supported near its end walls 141, 142 by bottom shell 12 within the substantially rectangular area of bottom shell 12 covered by top casing 11 and indicated by broken cross-hatched lines in Fig. 1b. As will be seen from Fig. 1a and 1b, tray 14 has almost the same length as the casing-covered area of bottom shell 12. Upper tray 16 is shorter but wider than lower tray 14.

As best seen from Fig. 1d, the recessed portion 121 of bottom shell 12 is wider than lower tray 14 but shorter than the latter so that two longitudinal air-passing gaps $ZS^1$, $ZS^2$ are formed between bottom shell 12 and lower tray 14.

Two transverse air-passing gaps $AS^1$, $AS^2$ are formed between end walls 141, 161 and 142, 162 of lower tray 14 and upper tray 16. The longitudinal air-passing gaps $ZS^1$, $ZS^2$ extend almost over the entire length (e.g. about 85 to 95 %) of the casing-covered area of bottom shell 12 while transverse air-passing gaps $AS^1$, $AS^2$ extend over a major portion (e.g. about 40 to 70 %) of the casing-covered area of bottom shell 12.

Returning to Fig. 1a, 1c it will be seen that a first or lower air-conducting space LR is formed between bottom shell 12, e.g. the recessed portion 121 thereof, and lower tray 14; a second or upper air-conducting space AR is formed between lower tray 14 and upper tray 16. Both air-conducting spaces have a generally flat configuration, i.e. their height is substantially smaller than either their width or their length;

in top view, these air-conducting spaces will have a generally rectangular shape.

The general function of the air-conducting spaces and notably the one (LR in the preferred embodiment) that opens into the longitudinal air-passing gaps ($ZS^1$, $ZS^2$) is to provide for a smooth and even flow of the air that usually has a certain turbulence near the blower; in other words, the air-conducting spaces serve as flow buffers between the unavoidable turbulence in the vicinity of the blower and the desired smooth or substantially laminar flow at the air-passing gaps, notably at those air-passing gaps where the air stream enters into the chamber space PR ($ZS^1$ and $ZS^2$ in Fig. 1b and 1c).

Following the air stream from blower rotor 150 through heating elements 17 into the first air-conducting space LR through the longitudinal air-passing gaps $ZS^1$, $ZS^2$ it will be seen (Fig. 1d) that two up-current air curtains $ZV^1$, $ZV^2$ will pass between the side walls 165, 166 of upper tray 16 and the adjacent side walls 117, 118 of top casing 11 so as to cover these major walls of the top casing with a dynamic insulation while passing the heated air essentially free of draft and turbulence into the chamber space PR.

The up-stream air curtains will converge at the inner surface of top wall 119 and then become divided again into two down-current streams that cover a major part of the inner surfaces of end walls 114, 115 of top casing 11 and then pass out of chamber space PR via the two transverse gaps $AS^1$, $AS^2$ formed between the end walls 141, 161 and 142, 162 of trays 14, 16.

After passing through the transverse air-passing gaps, the air streams will now pass into air-conducting space AR and converge near its center where opening 149 extends via conduit 147 to the suction end of blower 15.

Fresh air is allowed to enter into conduit 147 via conduit 159 supplied with a control valve (not shown); an optional branch conduit 157 is provided to supply pure oxygen if the air passed into the chamber is to contain an increased oxygen level. Conventional air filters may be provided at 158 in conduits 157; humidifier layers 19 (shown in broken lines in Fig. 1a) supplied with water from a conduit (not shown) may be arranged and operated as required.

Figure 2 shows a simplified perspective view of an incubator 20 according to the invention including a transparent top casing 21 upon bottom shell 221 which, in turn, is the upper closure of a central service portion 22 that comprises a main panel 229 (details not shown) for all parameters and data including monitoring, control and operation, an air entry port 223 and a water conduit 226; two handles 224, 225 are provided for lifting the foot end or the head end of the upper tray that carries the patient support; a weight-compensated mechanism (not shown) may serve to provide for a non-jolting change of position.

Because intensive care of baby patients may require long periods of continuous manipulation, it is desirable to provide for a lifting device so that the height position of incubator 20 may be adapted, e.g. via plunger 231, to the requirements of surgeons and nurses; to this end, the lower chassis portion 23 may be provided with a foot-controlled switch; rollers 234 are arranged for mobility of the unit and a "christmas tree" 25 is attached to support containers for infusion or transfusion liquids and auxiliary devices as needed.

Returning to the inventive incubator structure illustrated in Fig. 1a to 1d it should be added that tests made with such incubators have shown that with fresh air feeding rates of e.g. 25 liters per minute and with five measuring points distributed over the patient support suface, a maximum deviation of 0.5°C could be maintained at temperature settings of from 35 to 39°C without problems; low noise levels of 30 to 50 phon were obtained because of the smooth air flow.

Generally, trays 14, 16 should have rounded edges where possible to provide smooth flow and easy cleaning, and suitable integral structures may be obtained by molding or deep drawing of conventional polymer material; suitable materials for the trays and other components should be resistant to normal disinfection.

Various modifications of the inventive incubator will be apparent on the basis of the above specification. For example, the bottom shell 12 may consist of two complemental portions such that the control panel 229 can be withdrawn together with motor 151 and blower 15 to facilitate maintenance and repair.

Control of $CO_2$ can be achieved in a conventional manner and without particular removal means simply by means of fresh air supply rates of between 10 and 40 liters per minute; a typical incubator volume of 100 to 400 liters will ascertain that carbon dioxide is removed together with the surplus air; positive chamber pressures of 5 to 20 cm of water column are suitable for many purposes.

It will be noted that the preferred interfitting tray arrangement illustrated in Fig. 1d provides for optimum compactness of the novel air distribution means and, hence, an inventive incubator.

For a substantially complete interfit of the superimposed trays, the height of end walls 141, 142 of tray 14 will be greater than the height of end walls 161, 162, the height difference being determined by the desired "thickness" or height of the second or upper air distribution space; the longitudinal side walls 145, 146 of tray 14 will have a first portion where their height is the same as that of end walls 141, 142 and a second portion where they are recessed or "lowered" substantially by the height of side walls 165, 166 so as to receive tray 16 in a flush arrangement of all tray walls; a perfect flush is not critical, however, and non-flushing arrangements (Fig. 1a) may still be interfitting as long as the side walls of the lower tray have some recess, at least, to receive a portion, at least, of the height of the upper tray.

## C L A I M S

1. An incubator (10) for neonatology comprising a chamber (PR) substantially enclosed by a bottom shell (12) and a transparent top casing (11), the top casing (11) covering a substantially rectangular area of the bottom shell (12) and said casing-covered area having a length and a width, characterized by a pair of superimposed and substantially rectangular trays (14, 16)

   each having two longitudinal side walls (145, 165; 146, 166), two transverse end walls (141, 161; 142, 162) and a bottom (143, 164), the trays (14, 16) being arranged with their bottoms (143, 164) in a generally parallel and distanced relation when in normal operating condition, the lower tray (14) having substantially the same length as the casing-covered area and a width smaller than the casing-covered area, the upper tray (16) being shorter and wider than the lower tray (14) but having a width smaller than the casing-covered area;

   a first air-conducting space (LR) formed between the bottom shall (12) and the lower tray (14) and a second air-conducting space (AR) formed between the lower tray (14) and the upper tray (16); a pair of air-passing longitudinal gaps ($ZS^1$, $ZS^2$) formed between the tray (14) and the bottom shell (12), each longitudinal gap ($ZS^1$, $ZS^2$) communicating with the first air-conducting space (LR) and extending over a predominant portion, at least, of the length of the casing-covered area at each side wall (145, 146) of the lower tray (14), and a pair of transverse air-passing gaps ($AS^1$, $AS^2$) formed between the end walls (141, 161; 142, 162) of the upper tray (16) and the lower tray (14), each transverse gap communicating with the second air-conducting space (AR) and extending over a major portion, at least, of the width of the casing-covered area, and further characterized by

a blower (15) having its blowing end connected with one air-conducting space (LR, AR) and its suction end connected with the other air-conducting space (AR, LR).

2. The incubator of claim 1, wherein the blowing end of the blower (15) opens into the first air-conducting space (LR) and wherein the lower tray (14) has an opening (149) provided with a conduit (147) that extends from the second air-conducting space (AR) to the suction end of blower (15).

3. The incubator of claim 1, wherein the upper tray (16) comprises guide means (167, 168) for horizontal displacement of upper tray (16) relative to lower tray (14) and out of chamber (PR) when a lid portion (117) of top casing(11) is openend.

4. The incubator of claim 2, wherein a humidifier (19) is provided within the first air-conducting space (LR).

5. The incubator of claim 2, wherein the blower (15) is a radial blower (150) and wherein the bottom shell (12) includes a chamber (125) for receiving and enclosing the radial blower (150) and a means (17) for heating air that is passed through chamber (125) by blower (150).

6. The incubator of claim 1, wherein the upper tray (16) is made of a material that is substantially non-absorbent for X-rays and includes a recess (169) for receiving and holding an X-ray film material.

7. The incubator of claim 1, wherein the longitudinal side walls (145, 146) of lower tray (14) each have a recess for receiving upper tray (16) in an interfitting realtion.

8. The incubator of claim 7, wherein the lower tray (14) and the upper tray (16) form an easily dismountable assembly for separate disinfection of the trays (14, 16).

9. The incubator of claim 7, wherein both trays (14, 16) are formed by an integrally molded structure.

10. The incubator of claim 1, wherein the upper tray (16) includes a flat pad (163) of a soft material suitable for use as a patient support surface (160).

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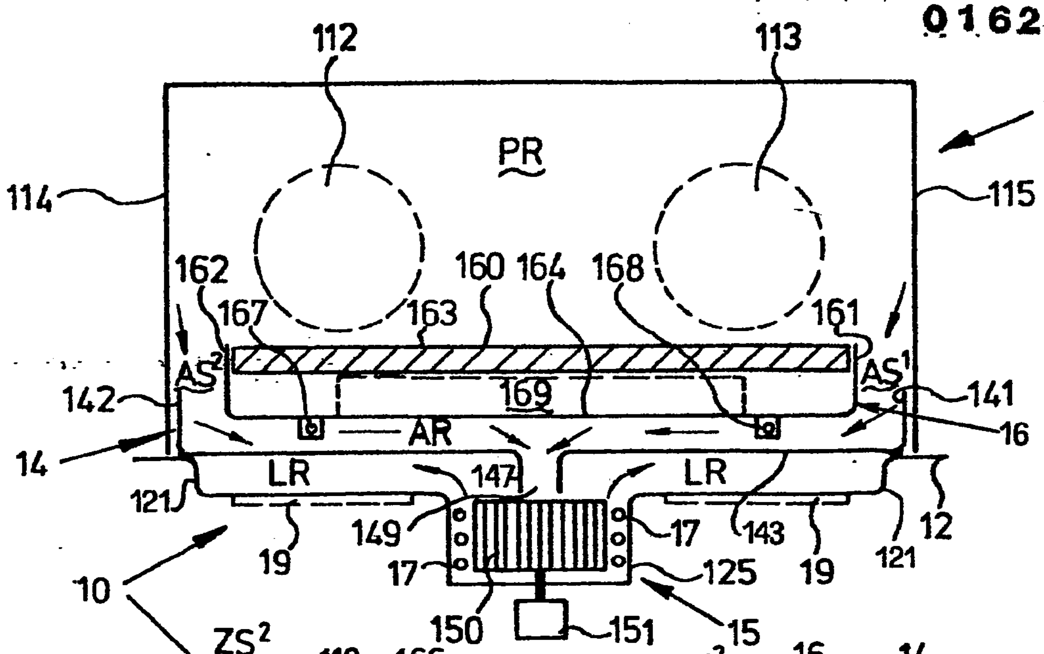


FIG. 1a

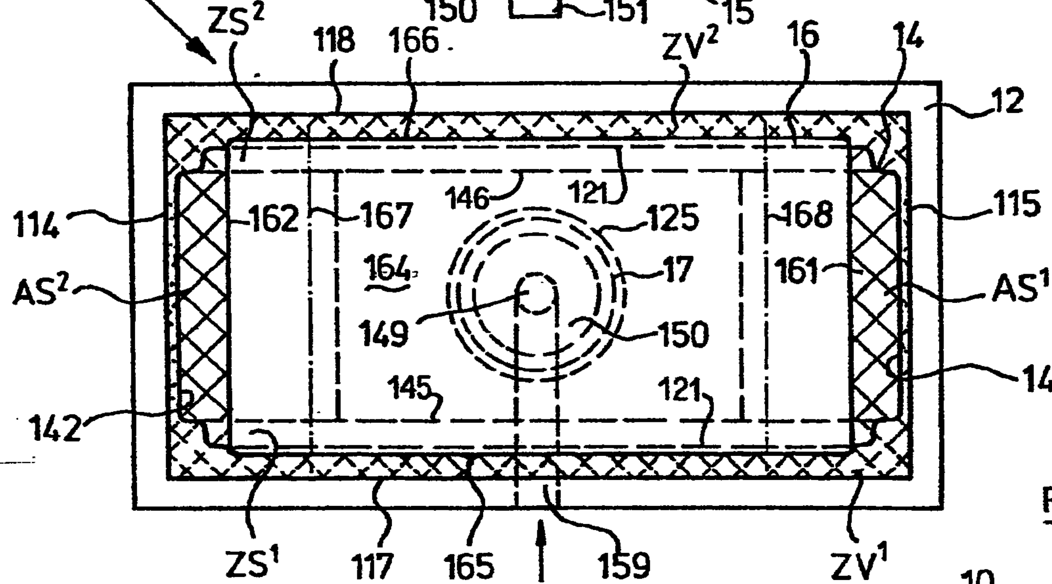


FIG. 1b

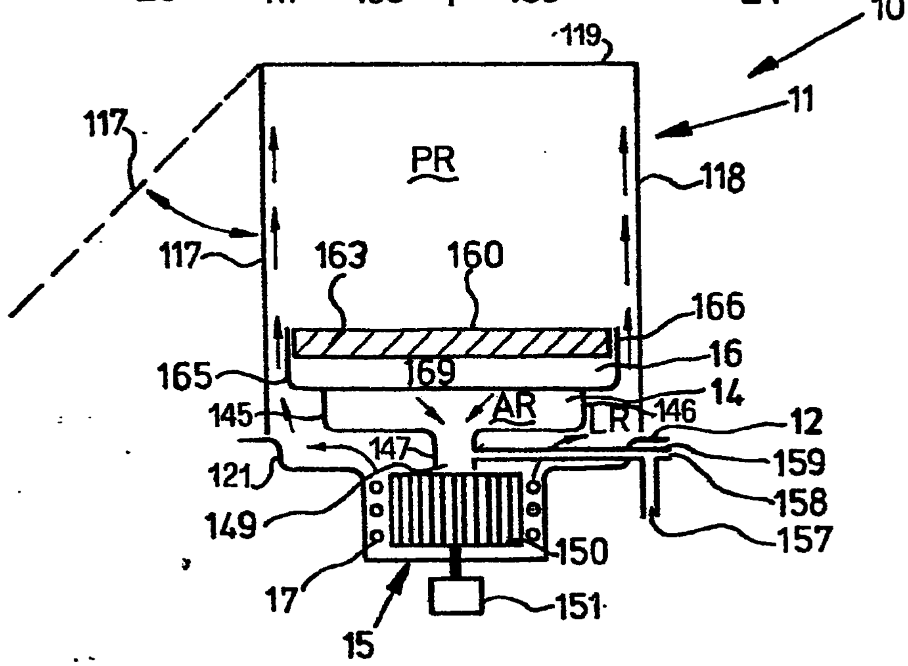


FIG. 1c

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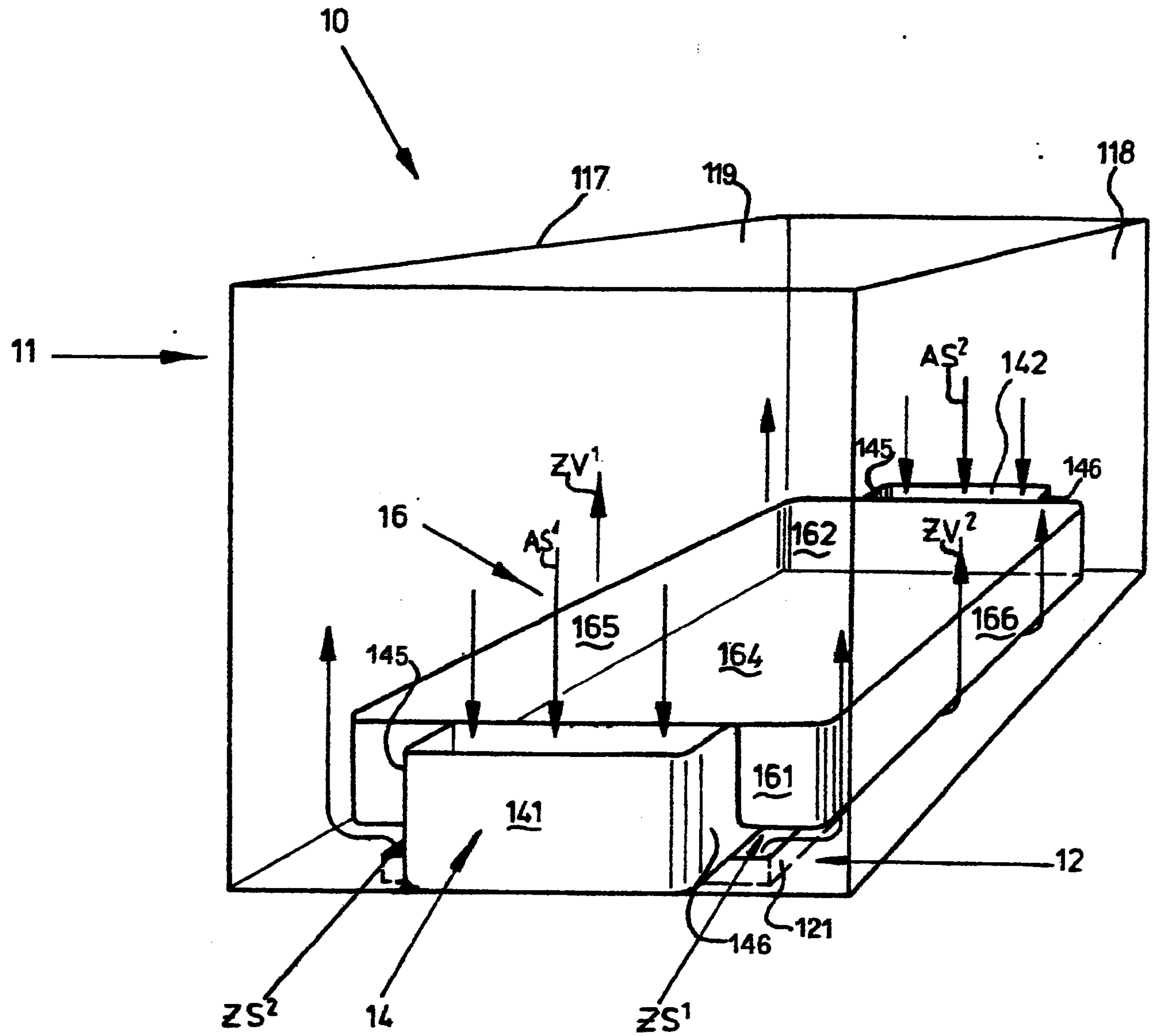


FIG. 1d

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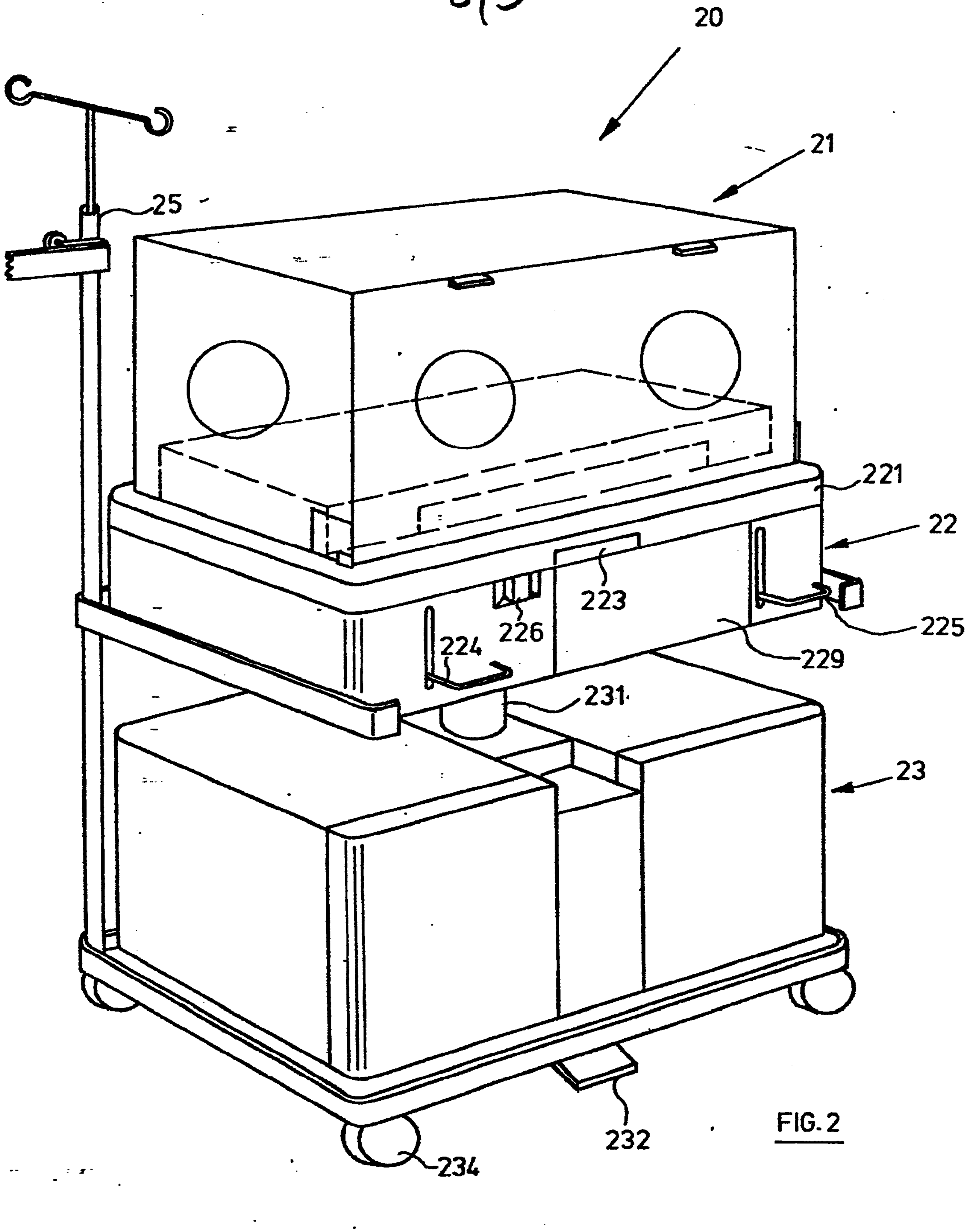


FIG. 2

European Patent Office

# EUROPEAN SEARCH REPORT

0162375
Application number

EP 85105669.7

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| A | US - A - 3 335 713 (GROSHOLZ)<br>* Fig. 1-5,9-14; column 4, lines 52-71; column 5, lines 25-61 * | 1-5,7,<br>8,10 | A 61 G 11/00 |
| A | US - A - 2 243 999 (CHAPPLE)<br>* Fig. 1,2,7,8; page 3; page 4, column 1, lines 12,24 * | 1-5,10 | |
| A | US - A - 2 246 820 (TAYLOR)<br>* Fig. 2; pages 2,3 * | 1,2,4,<br>5,10 | |
| A | GB - A - 1 501 281 (HOWORTH AIR ENGINEERING)<br>* Fig. 1,2,6-8 * | 1,2 | |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| | | | A 61 G 11/00 |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| VIENNA | 31-07-1985 | KRAL |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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